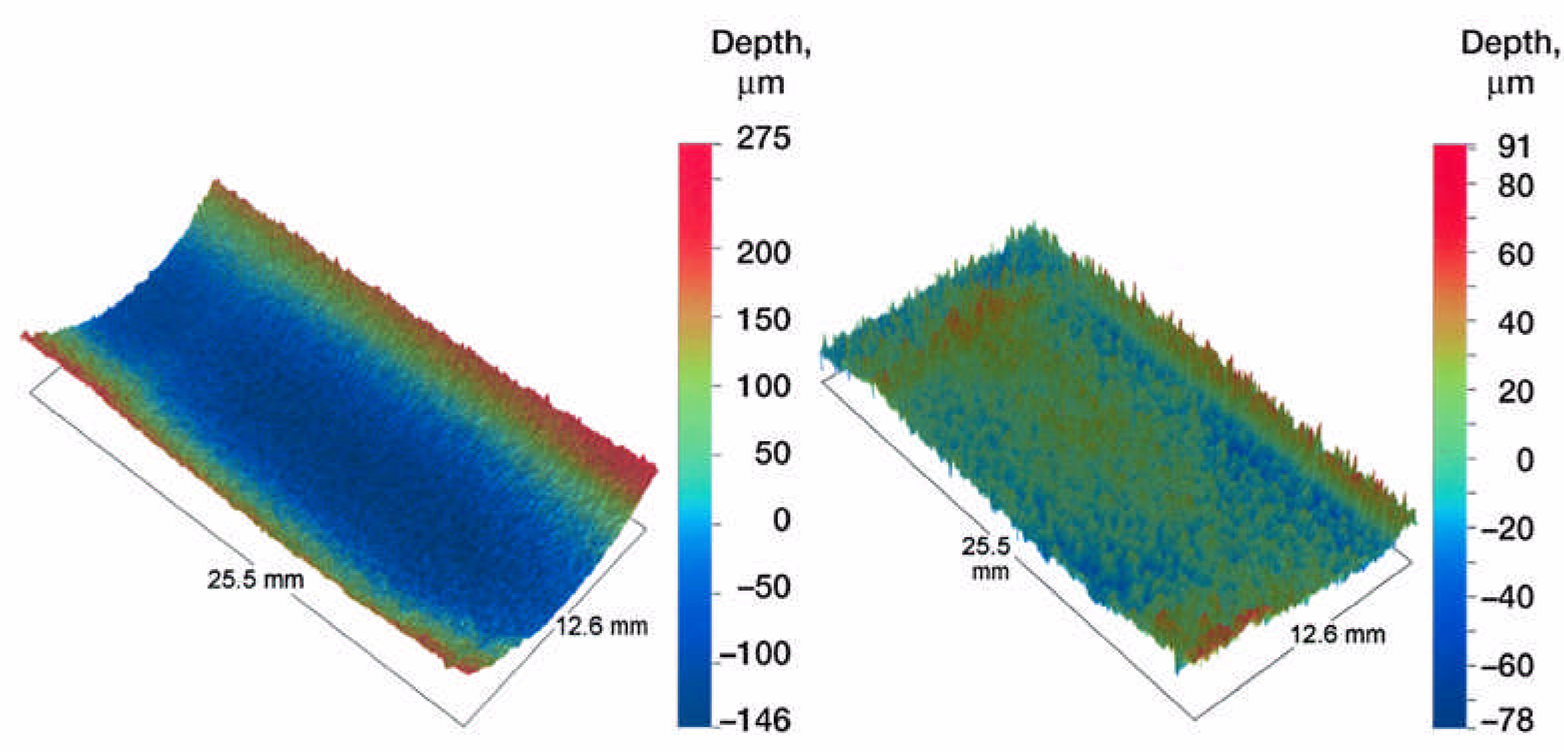
NASA Glenn/AADC-Rolls Royce Collaborated to Measure Erosion Resistance on Coated Polymer Matrix Composites

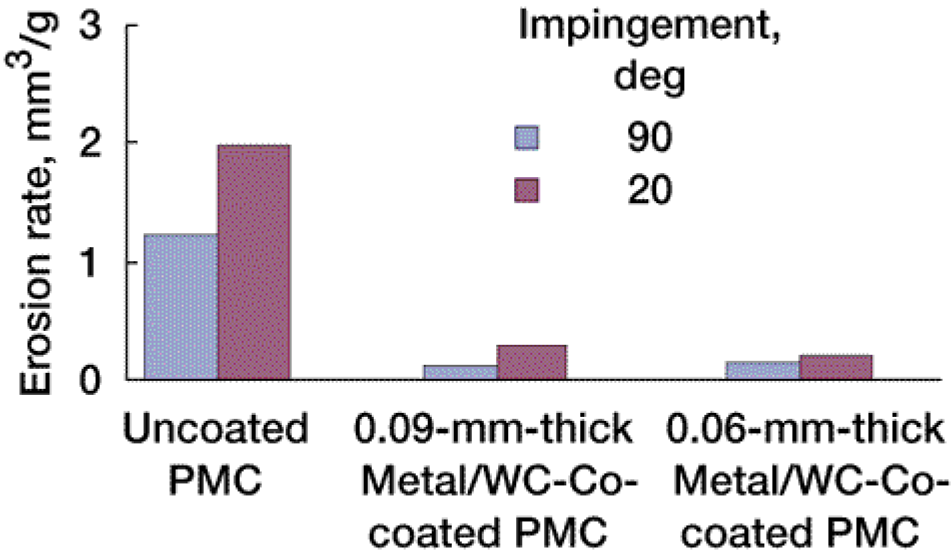
Polymer matrix composites (PMCs) are increasingly used in aerospace and automotive applications because of their light weight and high strength-to-weight ratio relative to metals. However, a major drawback of PMCs is poor abrasion resistance, which restricts their use, especially at high temperatures. Simply applying a hard coating on PMCs to improve abrasion and erosion resistance is not effective since coating durability is short lived (ref. 1). Generally, PMCs have higher coefficients of thermal expansion than metallic or ceramic coatings have, and coating adhesion suffers because of poor interfacial adhesion strength.

One technique commonly used to improve coating adhesion or durability is the use of bond coats that are interleaved between a coating and a substrate with vastly different coefficients of thermal expansion. An example of this remedy is the use of bondcoats for ceramic thermal barrier coatings on metallic turbine components (ref. 2). Prior collaborative research between the NASA Glenn Research Center and the Allison Advanced Development Company (AADC) demonstrated that bond coats sandwiched between PMCs and high-quality plasma-sprayed, erosion-resistant coatings substantially improved the erosion resistance of PMCs (ref. 3). One unresolved problem in this earlier collaboration was that there was no easy, accurate way to measure the coating erosion wear scar. Coating wear was determined by both profilometry and optical microscopy. Both techniques are time consuming. Wear measurement by optical microscopy requires sample destruction and does not provide a comprehensive measure of the entire wear volume.



Three-dimensional optical interferometry images of the eroded wear scar of a coated PMC sample obtained after an erosion test. The eroded surface appears as a large scar containing abrasive particles in the direction of the airstream. The erosion test was conducted with Arizona Road Dust particles at an impingement angle of 20° and a velocity of 229 m/s. Left: From measurement. Right: Removed cylindrical shape.

An even more subtle, yet critical, problem is that these erosion coatings contain two or more materials with different densities. Therefore, simply measuring specimen mass loss before and after erosion will not provide an accurate gauge for coating and/or substrate volume loss. By using a noncontact technique called scanning optical interferometry, which was recently developed at Glenn, researchers can accurately determine the wear performance of erosion-coated PMCs while preserving the sample. An example of this interferometry technique is shown in the preceding figure for an erosion-coated inlet guide vane from a Rolls Royce AE3007 regional gas turbine jet engine. Erosion was conducted with coated and uncoated PMC vanes, with the abrasive material moving at a velocity of 229 m/s at impingement angles of 20° and 90°. The coatings for PMCs remarkably reduced the erosion volume loss by a factor of approximately 10 (see the following bar chart). Currently, several erosion coatings for PMCs are being compared and down-selected for engine testing at Rolls Royce.



Erosion rate of uncoated and coated PMC samples measured by scanning optical interferometry. Erosion tests were conducted at a velocity of 229 m/s with Arizona Road Dust particles at impingement angles of 20° and 90°. Coated PMCs had lower erosion rates by a factor of ~10.

Find out more about the research of Glenn's Polymers Branch http://www.grc.nasa.gov/WWW/MDWeb/5150/Polymers.html.

References

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